

Claims

1. A method of focussing a lens arrangement in a camera which further comprises an image sensor onto which an image is focussed by the lens arrangement and a piezoelectric actuator arranged to drive movement of the lens arrangement in accordance with a control signal applied thereto to vary the focus of the image on the image sensor, the piezoelectric actuator experiencing hysteresis in the position to which it drives the lens arrangement as a function of the control signal, the method comprising:
  - 10 applying a control signal to the piezoelectric actuator with a value at an extreme of a predetermined range;
  - changing the control signal monotonically across the predetermined range and at each of a plurality of test values of the control signal during the change of the control signal determining a respective measure of the quality of the focus of the image from the image signal output by the image sensor;
  - 15 determining, from said respective measures of the quality of the focus of the image, a focus value of the control signal at which the quality of the focus of the image is at an acceptable level;
  - changing the control signal back to said value at an extreme of said predetermined range;
  - and
  - 20 changing the control signal monotonically to said focus value.
2. A method according to claim 1, wherein said determining of a focus value of the control signal comprises selecting one of said test values of the control signal;
- 25 3. A method according to claim 2, wherein said selecting of one of said values of the control signal comprises selecting the one of said values at which the measure of the quality of the focus of the image is best.
4. A method according to any one of the preceding claims, wherein the control signal is a voltage signal.
- 30 5. A method according to any one of claims 1 to 3, wherein the control signal is a charge signal.
6. A method according to any one of the preceding claims, wherein said method 35 is performed repeatedly using the same predetermined range.

7. A camera comprising:
  - an image sensor;
  - a lens arrangement which focusses an image onto the image sensor;
  - a piezoelectric actuator arranged to drive movement of the lens arrangement in accordance with a control signal applied thereto to vary the focus of the image on the image sensor, the piezoelectric actuator experiencing hysteresis in the position to which it drives the lens arrangement as a function of the control signal; and
    - a control circuit arranged to apply the control signal to the piezoelectric actuator and being operable to automatically focus the image by:
- 10 applying a control signal with a value at an extreme of a predetermined range;
  - changing the control signal monotonically across the predetermined range and at each of a plurality of test values of the control signal during the change of the control signal determining a respective measure of the quality of the focus of the image from the image signal output by the image sensor;
- 15 determining, from said respective measures of the quality of the focus of the image, a focus value of the control signal at which the quality of the focus of the image is at an acceptable level;
  - changing the control signal back to said value at an extreme of said predetermined range;
  - and
- 20 changing the control signal monotonically to said focus value.

8. A camera according to claim 7, wherein said determining of a focus value of the control signal comprises selecting one of said test values of the control signal;

- 25 9. A camera according to claim 8, wherein said selecting of one of said values of the control signal comprises selecting the one of said values at which the measure of the quality of the focus of the image is best.

10. A camera according to any one of claims 7 to 9, wherein the control signal is
- 30 a voltage signal.

11. A camera according to any one of claims 7 to 9, wherein the control signal is a charge signal.

- 35 12. A camera according to any one of claims 7 to 11, wherein the control circuit is operable to automatically focus the image repeatedly by said steps using the same predetermined

range

13. A method of focussing a lens arrangement in a camera which further comprises an image sensor onto which an image is focussed by the lens arrangement and a piezoelectric actuator arranged to drive movement of the lens arrangement in accordance with a control signal applied thereto to vary the focus of the image on the image sensor, the piezoelectric actuator experiencing hysteresis in the position to which it drives the lens arrangement as a function of the control signal, the method comprising:

10 applying a control signal to the piezoelectric actuator with a value at an extreme of a predetermined range;

changing the control signal monotonically across the predetermined range and at each of a plurality of values of the control signal during the change of the control signal determining a respective measure of the quality of the focus of the image from the image signal output by the image sensor;

15 determining, from said respective measures of the quality of the focus of the image, a focus value of the control signal at which the quality of the focus of the image is at an acceptable level;

20 determining a modified value of the control signal which is capable, by monotonic change of the control signal to the modified value, of moving the lens arrangement to the position at which it was located when the control signal was at the focus value of the control signal, taking into account the hysteresis of the piezoelectric actuator; and

25 changing the control signal monotonically to said modified value.

14. A method according to claim 13, wherein said determining of a focus value of the control signal comprises selecting one of said test values of the control signal;

15. A method according to claim 14, wherein said selecting of one of said values of the control signal comprises selecting the one of said values at which the measure of the quality of the focus of the image is best.

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16. A method according to any one of claims 13 to 15, wherein the control signal is a voltage signal.

17. A method according to any one of claims 13 to 15, wherein the control signal is a charge signal.

18. A method according to any one of claims 13 to 17, wherein said method is performed repeatedly using the same predetermined range.

19. A camera comprising:

5 an image sensor;  
a lens arrangement which focusses an image onto the image sensor;  
a piezoelectric actuator arranged to drive movement of the lens arrangement in accordance with a control signal applied thereto to vary the focus of the image on the image sensor, the piezoelectric actuator experiencing hysteresis in the position to which it drives the lens  
10 arrangement as a function of the control signal; and  
a control circuit arranged to apply the control signal to the piezoelectric actuator and being operable to automatically focus the image by:  
applying a control signal to the piezoelectric actuator with a value at an extreme of a predetermined range;

15 changing the control signal monotonically across the predetermined range and at each of a plurality of values of the control signal during the change of the control signal determining a respective measure of the quality of the focus of the image from the image signal output by the image sensor;

determining, from said respective measures of the quality of the focus of the image, a  
20 focus value of the control signal at which the quality of the focus of the image is at an acceptable level;

determining a modified value of the control signal which is capable, by monotonic change of the control signal to the modified value, of moving the lens arrangement to the position at which it was located when the control signal was at the focus value of the control signal, taking into  
25 account the hysteresis of the piezoelectric actuator; and

changing the control signal monotonically to said modified value.

20. A camera according to claim 19, wherein said determining of a focus value of the control signal comprises selecting one of said test values of the control signal;

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21. A camera according to claim 20, wherein said selecting of one of said values of the control signal comprises selecting the one of said values at which the measure of the quality of the focus of the image is best.

35 22. A camera according to any one of claims 19 to 21, wherein the control signal is a voltage signal.

23. A camera according to any one of claims 19 to 22, wherein the control signal is a charge signal.

24. A camera according to any one of claims 19 to 23, wherein the control circuit 5 is operable to automatically focus the image repeatedly by said steps using the same predetermined range

25. A camera comprising:

an image sensor arranged to generate an image signal;  
10 a lens arrangement which focusses an image onto the image sensor, the focus being variable in accordance with a control signal applied thereto;  
an encoder arranged to encode the image signal from the image sensor into an encoded signal compressed form;  
a control circuit arranged to control the focus of the lens arrangement by applying said 15 control signal to the lens arrangement,

wherein

the control circuit is capable of controlling the encoder to operate in two modes, wherein in the first mode the encoded signal preserves low spatial frequency components of the image signal preferentially and in the second mode the encoded signal preserves high spatial frequency 20 components of the image signal preferentially, and  
the control circuit is operative to control the focus of the image by:  
controlling the encoder to operate in said second mode;  
determining the amount of data in the encoded signal as a measure of the quality of the focus of the image on the image sensor;  
25 controlling the focus of the lens arrangement on the basis of the determined amount of data; and  
subsequently controlling the encoder to operate in said first mode.

26. A camera according to claim 25, wherein

30 the encoder comprises a JPEG encoder comprising:  
a discrete cosine transformation block arranged to transform the image signal into spatial frequency components;  
a quantisation block arranged to quantise the spatial frequency components output from the discrete cosine transformation block in accordance with a matrix of quantisation levels each in 35 respect of a respective spatial frequency component; and  
an encoder block arranged to encode the quantised image signal in the frequency domain

output from the quantisation block, and

the control circuit is capable of controlling the encoder to operate in said two modes by causing the quantisation block to use different respective matrices of quantisation levels.

5 27. A camera according to claim 25 or 26, wherein in the second mode the control circuit causes the quantisation block to use a matrix of quantisation levels which is the reciprocal of a matrix of spatial frequency coefficients of a high-pass filter.

28. A camera according to claim 27, wherein said high-pass filter is the Laplacian  
10 of a Gaussian filter.

29. A camera according to any one of claims 25 to 28, wherein variable focus lens arrangement comprises an actuator arranged to drive movement of the lens arrangement in accordance with the control signal applied thereto to vary the focus of the image on the image  
15 sensor

30. A camera according to claim 29, wherein the actuator is a piezoelectric actuator.

20 31. A camera according to any one of claims 25 to 30, wherein said step of controlling the focus of the lens arrangement on the basis of the determined amount of data comprises controlling the focus of the lens arrangement to minimise the determined amount of data.

25 32. A camera comprising:  
an image sensor arranged to generate an image signal;  
a lens arrangement which focusses an image onto the image sensor, the focus being movable to vary the focus of the image;  
a light source;  
30 an optical element fixed to and movable with the lens arrangement, and arranged to receive light from the light source and to direct it onto the image sensor, the optical element being arranged so that movement of the lens arrangement causes variation in the light incident on the image sensor; and  
a signal processor supplied with the image signal from the image sensor and arranged to  
35 detect said variation in the light incident on the image sensor and, on the basis of the detected variation, to generate a measure of the position of the lens arrangement.

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33. A camera according to claim 32, wherein the optical element is a reflector arranged at an angle of greater than  $0^\circ$  to the axis along which the lens arrangement is movable.

34. A camera according to claim 32 or 33, wherein the light source produces a  
5 beam of light.

35. A camera according to claims 32 to 34, wherein the signal processor is further arranged to replace the light from the image sensor in the image signal with estimated data.

10 36. A camera according to claims 32 to 35, wherein the camera comprises a controller arranged to control the movement of the lens arrangement to vary the focus on the basis of at least the generated measure of the position of the lens arrangement.

15 37. A camera according to claims 32 to 35, wherein the signal processor and the controller are both implemented by a microprocessor running a program.

38. A method of detecting the position of a movable lens arrangement which focusses an image onto a image sensor in a camera and which is movable to vary the focus of the image, the method using a light source and an optical element which is fixed to and movable with the lens  
20 arrangement, and arranged to receive light from the light source and to direct it onto the image sensor, the optical element being arranged so that movement of the lens arrangement causes variation in the light incident on the image sensor,

the method comprising detecting said variation in the light incident on the image sensor and, on the basis of the detected variation, generating a measure of the position of the lens  
25 arrangement.